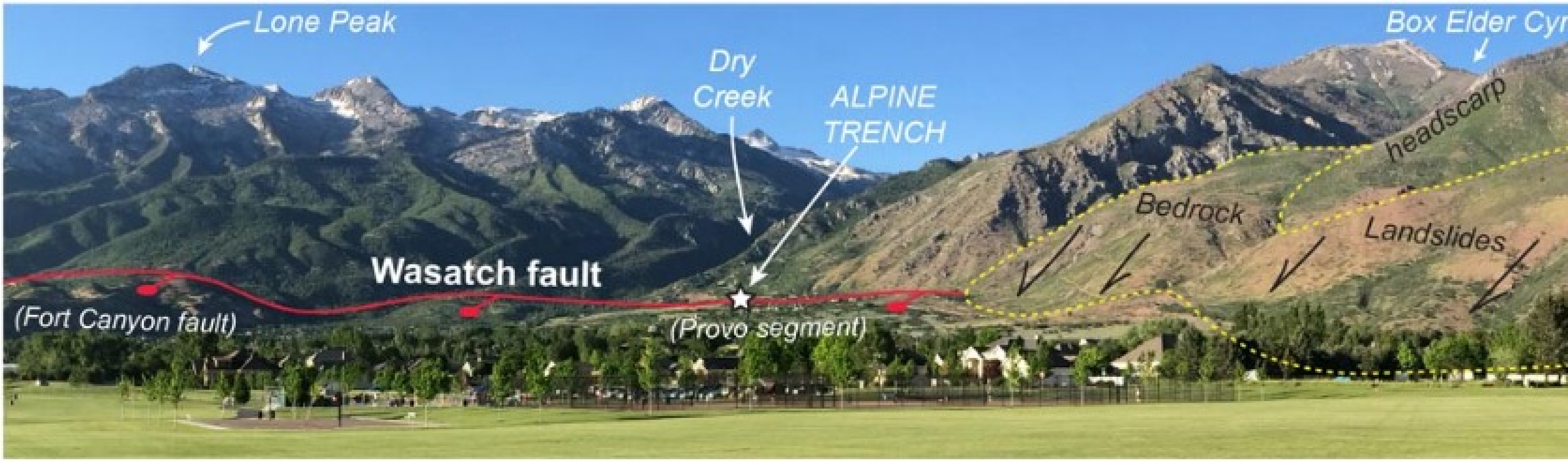
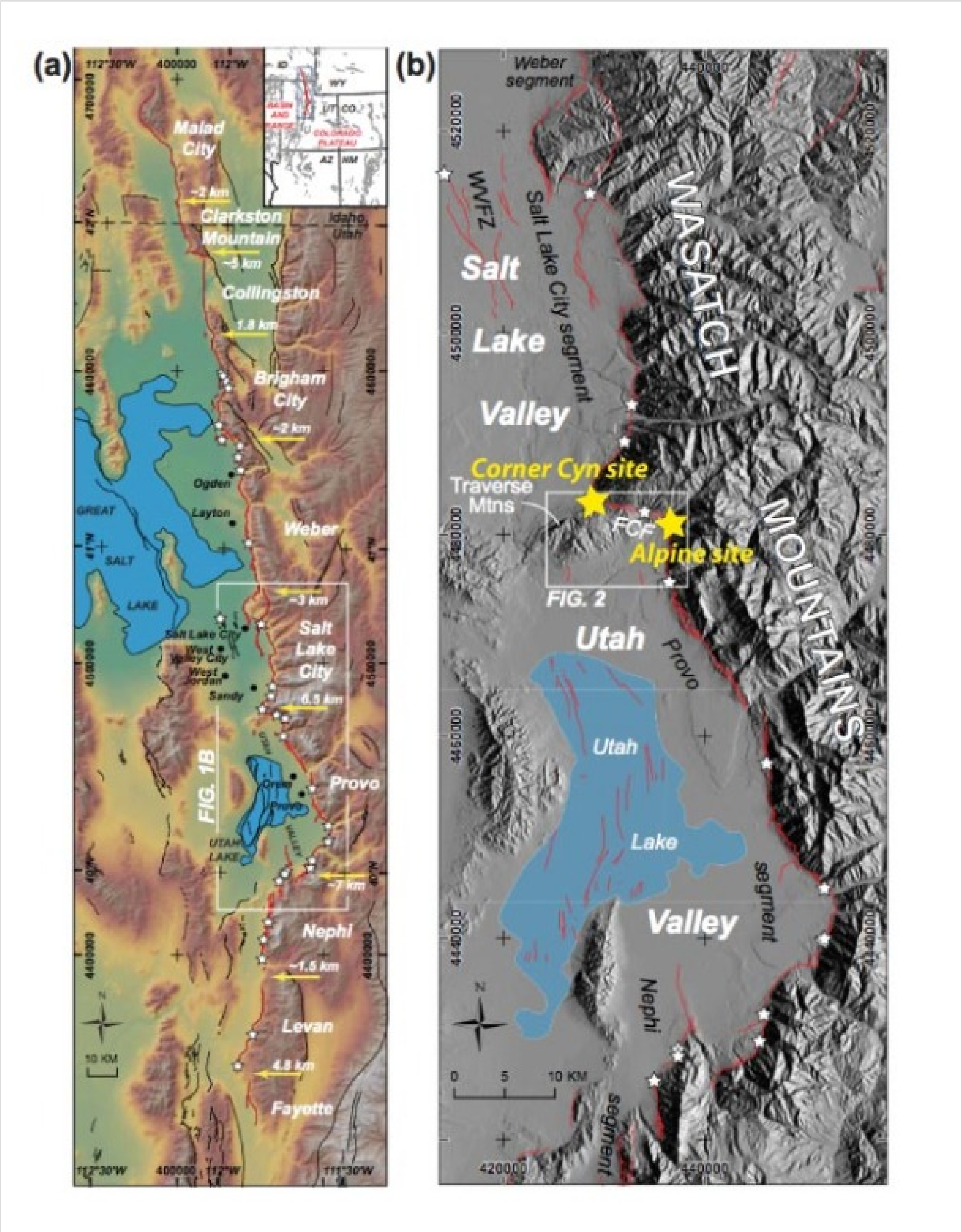
Segments of the Wasatch Fault Zone: Do They Act Alone or Together?



View to the northeast from central Alpine, Utah of the northern Provo segment of the Wasatch fault zone. The Alpine trench (white star) is located less than 1 km south of the northern end of the Provo segment near the mouth of Dry Creek.

The Wasatch fault zone in Utah follows the western edge of the Wasatch Range for about 350 km (218 mi), posing a significant earthquake hazard to the Wasatch Front urban corridor. The fault zone consists of at least 10 fault segments, each thought to be individually capable of generating large (M~7) ground-rupturing earthquakes. Although there have been past studies on the individual segments, whether or not the segments rupture together in large earthquakes is not well understood. An earthquake that ruptures several fault segments simultaneously will be much larger than one involving rupture of only one segment.

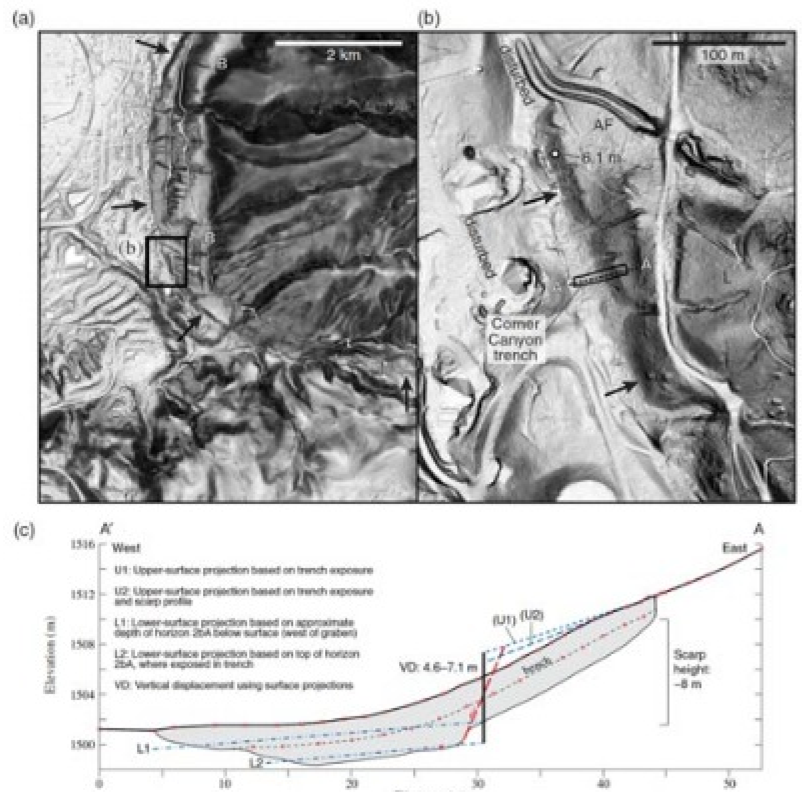
Two recent paleoseismic (ancient earthquake) studies of the Wasatch fault zone set out to investigate past fault ruptures near a boundary between two prominent segments––the Provo and Salt Lake City segments. In these investigations, geologists studied exposures of geologic units faulted by large earthquakes in two trenches dug across the Wasatch fault zone. The trench locations were on the southernmost part of the Salt Lake City segment near Draper, Utah (the Corner Canyon site) and the northernmost part of the Provo segment near Alpine, Utah (the Alpine site). The joint goal of these studies was to determine whether or not any prehistoric earthquakes have involved both fault segments.



A close-up view of the Salt Lake City and Provo segments of the Wasatch fault zone, indicated by the white rectangle in map (a). The two trench sites (yellow stars) from these studies are located on either side of the boundary between these two fault segments.

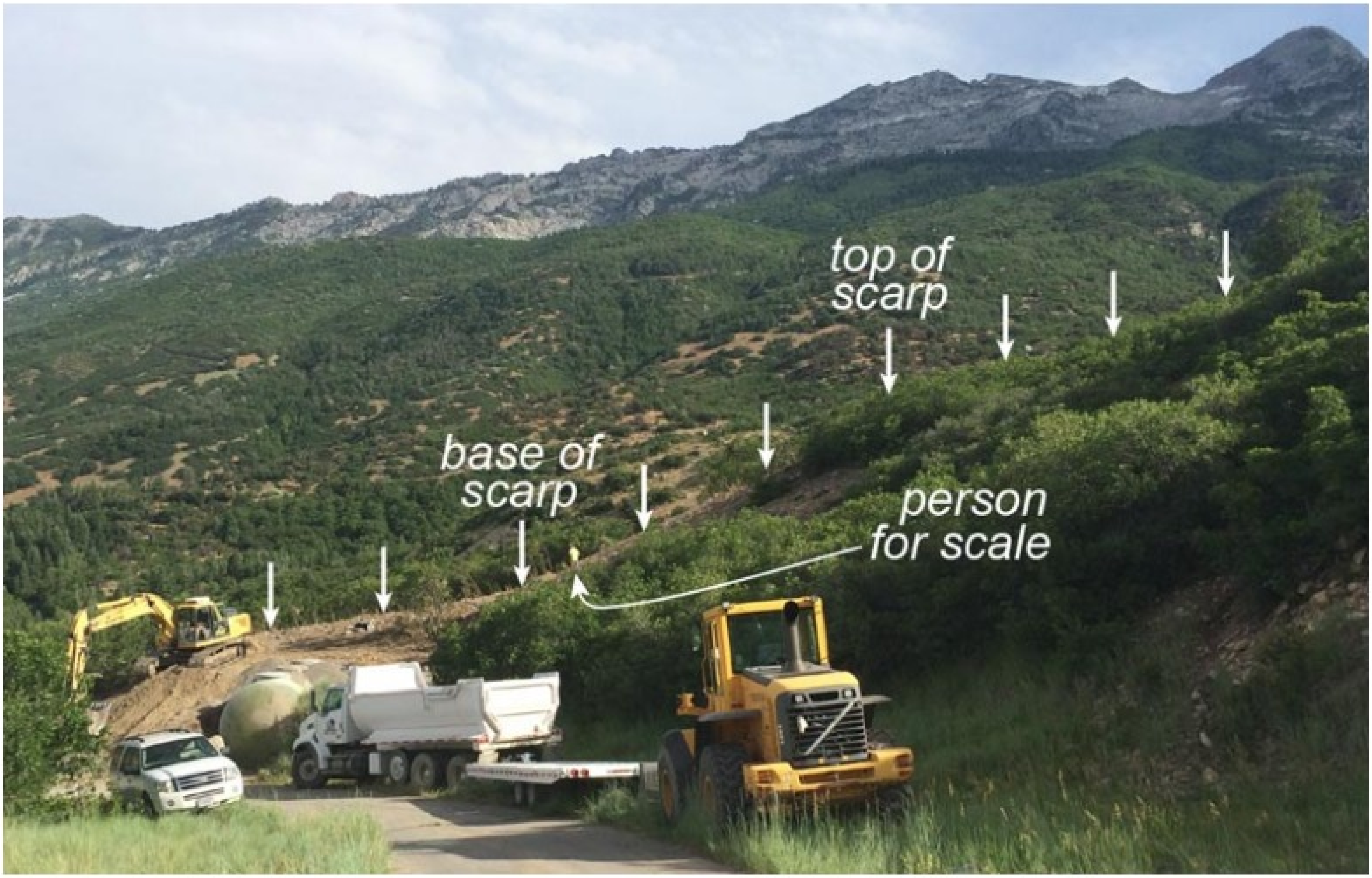
At the Corner Canyon site, the scientists found geologic evidence of six ground-rupturing earthquakes on the Salt Lake City segment in the last 4800 years. The time between earthquakes ranges from 300 to 1600 years, and individual fault offsets vary from 0.7 to 1.2 m (about 3 ft). For this study, the scientists developed a multiple-method approach to evaluate and model the timing of individual earthquakes at the site. Paleoseismologists typically analyze collected data using Bayesian (probabilistic) statistical analysis, which works well in a geological environment where earthquakes occur among a continuous and uninterrupted sedimentary record. The Bayesian approach does not work as well when the sedimentary record is sporadic and/or affected by processes such as weathering and bioturbation (mixing from plants and burrowing animals). The new method developed in this study uses a multiple-method approach to more accurately assess earthquake timing. In this approach, all of the geologic data are evaluated in multiple models; earthquake timing data from these models are then combined to determine the history of earthquakes at the site. The result is more likely to be the actual sequence that took place, but the uncertainty around the exact earthquake dates is larger. This approach and is applicable to any geologic environment that yields data that are complex or difficult to interpret.

a) The Corner Canyon trench site at the beginning of the digging process. The small black and white arrows highlight the top and bottom of the fault scarp, respectively. b) Looking east at the Corner Canyon trench after the excavation was completed. The black line across trench shows the location of the Wasatch fault, where it juxtaposes different color geologic units (tan and brown).



Maps of the Corner Canyon site showing a) an overview of the area and b) a close-up view of the rectangular area shown in map (a) with the trench drawn in as a rectangle and dashed line. c) This topographic profile (cross section) shows how geologists calculate the total ground offset from several prehistoric earthquakes.

At the Alpine trench site, the scientists documented six earthquakes on the Provo segment during the last 6000 years. Soil and sediment from the fault zone was dated to determine the approximate sequence and timing of the six earthquakes. The time between individual earthquakes ranges from 200 to 1800 years, and the fault displacement in each earthquake, or the measure of how much the ground surface was vertically displaced by fault movement, varies from 0.8 to 1.2 m (about 3 ft). The earthquakes had approximate surface-rupture lengths of 25 to 52 km (16-32 mi), which roughly translates into magnitude estimates of 6.9 to 7.0. The scientists in this study also refined a method that uses the amount of sediment that collapses off of a fault scarp to estimate the fault offset at that location. This method also helps to understand the length of the ruptured fault and the magnitude of past earthquakes.



A photo from the Alpine site showing the extent of the trench across the Wasatch fault (white arrows), as well as the top and bottom of the scarp caused by vertical offset from past earthquakes.

Collectively, the results from these two scientific studies demonstrate the history of large earthquakes on either side of the boundary between the Salt Lake City and Provo segments. These data will help fill in the complex puzzle of what is going on along the Wasatch fault zone and what we might expect to happen during the next large earthquake along the Wasatch Front. The scientists plan to continue analyzing these data, as well as all previous paleoseismic data for this part of the Wasatch fault zone, to evaluate whether this boundary has broken during recent earthquakes. Results anticipated from this study will help scientists to better understand the history of strong shaking along this part of the Wasatch Front and the probability of a future large earthquake in the region.

- written by Lisa Wald, U.S. Geological Survey, July 11, 2018

A photo of one exposed wall of the Alpine trench showing the Wasatch fault and the sense of motion on the fault (red lines and arrows). The alluvial fan deposits are shown by the dashed white lines.

For More Information

- How Big and How Frequent Are Earthquakes on the Wasatch Fault?
- Christopher B. DuRoss, Scott E. K. Bennett, Richard W. Briggs, Stephen F. Personius, Ryan D. Gold, Nadine G. Reitman, Adam I. Hiscock, Shannon A. Mahan; 2018, Combining Conflicting Bayesian Models to Develop Paleoseismic Records: An Example from the Wasatch Fault Zone, Utah. Bulletin of the Seismological Society of America doi: https://doi.org/10.1785/0120170302
- Bennett, S. E. K., DuRoss, C. B., Gold, R. D., Briggs, R. W., Personius, S. F., Reitman, N. G., DeVore, J. R., Hiscock, A. I., Mahan, S. A., Harrison, G. J., Gunnarson, S., Stephenson, W. J., Klein, T., Pettinger, E., and Odum, J. K., 2018, Paleoseismic Results from the Alpine Site, Wasatch Fault Zone: Timing and Displacement Data for Six Holocene Earthquakes at the Salt Lake City-Provo Segment Boundary, Bulletin of the Seismological Society of America.

The Scientists Behind the Science

Chris DuRoss.

Chris DuRoss is a Research Geologist with the USGS in Golden, Colorado. As a paleoseismologist, he studies geologic evidence of large, prehistoric earthquakes in areas of active faulting such as the Wasatch Front. When not working, he can be found (or not) with his family in the remote parts of the West.

Scott Bennett.

Scott Bennett is a geologist with the USGS who studies the deformation and evolving landscape of continents, collecting data that allows him to reconstruct tectonic movements over a large range of temporal and spatial scales, from earthquakes to orogenies and from faults to plate boundaries. When not conducting research, he enjoys hiking or biking up mountains, hanging out at the beach with his family, and a spirited game of cribbage.